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AIRCRAFT DRAWING-DIE DESIGN CAD EXPERT SYSTEM BASED ON ENGINEERING GRAPH

Fu Xiangyang, Gao Guangdao and Yang Peng

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The features of engineering CAD expert systems are discussed and an ADDES system Aircraft Drawing-Die Design CAD Expert System) is built. Based on the construction of the DIE coding system, such methods as the feature-based code system are used to establish a customer model. The agents in the system have the ability to solve partial problems, and the system is organized into distributed and hierarchical forms. The system synthetically utilizes blackboard structure, meta-reasoning and so on to control the problem solving process. As discussed above, the problems such as low efficiency etc caused by building a large knowledge base can be solved and the cooperation of many experts can be attained.

KEY WORDS: Computer aided design, expert systems, knowledge bases, artificial intelligence.

Artificial intelligence and expert system theory has already begun to be used in engineering designs, such as its use in machinery design CDDES systems [1], DOMINIC tools [2] and its application in electronic technology ASDEP [3].

Current applications of CAD and intelligence technology model design are primarily in such fields as drawing dies. Because of the complexity of the drawn parts, the die design primarily is done manually with some CAD technology. There are currently a number of insufficiencies in die design applications of CAD. The design process is basically localized and in stages. The range of die CAD system design is narrow, basically focussed on a certain type or a number of types of parts. The system is not expandable. The design results are poor. However, the growth of expert systems and artificial intelligence has done a good job in expanding the applications of CAD.

This article will use the establishment of an ADDES system to study how to control the die CAD process around the use of expert systems. Through the combination of the accumulation and rationale of expert knowledge and CAD technology and the effective expression and application of knowledge to make die design highly effective and high quality. The running environment of the ADDES system was CDC CYBER 180/830 and PC series machines. Graphics software was DI-3000. When the system was checked and accepted, initial use stages were run with marked results.

1. STRUCTURE OF THE ADDES EXPERT SYSTEM

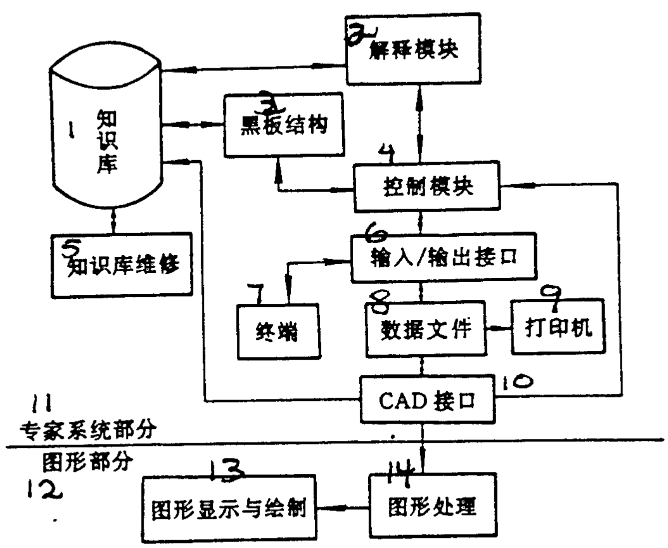

Fig. 1: Composition of the ADDES system

Key: 1. Knowledge bank. 2. Interpretation module. 3. Blackboard structure. 4. Control module. 5. Knowledge bank maintenance. 6. Input/output interface. 7. Terminal. 8. Data documents. 9. Printer. 10. CAD interface. 11. Expert system portion. 12. Graphics portion. 13. Graphics display and plotting. 14. Image processing.

The use of CAD technology to perform graphics display and blueprint drafting is extremely important in the process of designing and forming the dies required by parts. The die design includes the following characteristics:

In the design, it is necessary to use heuristic knowledge to perform the reasoning, and their are stringent complex calculations. CAD expert systems require combining the technologies of CAD technology and expert system reasoning.

The design process can be broken down, allowing the design to be performed step-by-step in stages.

Design type expert systems involve knowledge over a wide area such as what types of tables are to be used in the die design, what kind of standards structure and standard parts, what type of expression of knowledge is required such as rules, outlines or documents.

The structure of the ADDES expert system is shown in Figure 1. In addition to the knowledge bank and controller, it also has such portions as a man/machine interface, interpretation module and knowledge bank maintenance module. The ADDES system uses the CAD interface to connect the two portions of the system - the expert system portion and the graphics output portion. The CAD software package for analysis and computing contained in the knowledge bank also uses the CAD interface to serve the reasoning and design of the entire system. The system can make comprehensive use of all sorts of CAD software, technology and expert system technology to make the system intelligent.

The expert system portion of the ADDES system is the heart of the system. The control structure is composed of the control module and the blackboard. The graphics output portion uses graphics CAD technology and software for image processing of the design results transmitted by the expert system which is displayed on a monitor. It can also output actual die engineering diagrams.

2. ESTABLISHING CUSTOMER MODELS

The establishment of a DIE part characteristic coding system [5] allows for the description of the geometric characteristics of the part and the providing of processing information. On the basis of the coding, the ADDES system using a combination of a description of the characteristic factors of the graphics and outlining methods to accurately describe the graphics information. This greatly reduces the amount of information to be stored over that of ordinary CAD systems. It is easy for the customer to use, and the internal portions are easily and effective to use.

The die coding system a comprehensive coding structure similar to the Opitz code. A die assembly illustration it plotted is shown in Figure 2. The DIE coding includes 11 positions in two pats, the shape characteristic coding and the supplementary coding. The system reproduces the graphics of the part image input by the

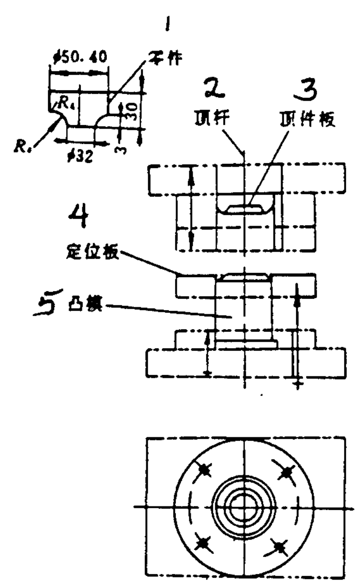

Fig. 2: Die assembly diagram plotted by system
Key: 1. Part. 2.Top. 3. Top die. 4. Positioning die. 5. punch.

customer on the graphics terminal to allow the customer to compare this to the input and output data of the character terminal for evaluation and alteration.

3. REPRESENTATION AND ORGANIZATION OF KNOWLEDGE

3.1. Composition of the Knowledge Bank

The knowledge bank of the ADDES system is composed of a data bank, fact bank, rules bank, formula bank, process bank and standard element bank. In the rules bank there are initiating rules. In ordinary control and diagnostic systems, the central element of the rules conditions portion and the conclusion portion is the factual format. It is very difficult for this to meet the requirements of engineering design. In ADDES, the rules combine the forms of procedure calling, computation, factual and control. The following rule was used in designing the parameters of a tubular part with a flange:

```
(RULE3] (IF  99< BIGORSMALL-FLANGE) 1.4)))
(THEN (ADD-LIST (DEDUCE FU SET5-2))
(EXECUTE SCHEDULE-LIST))))
```

Herein, (BIGORSMALL-FLANGE) is a procedure parameter, the ratio of the flange to the diameter. DEDUCEFU performs positive reasoning of the rules in SET5-2 in the rule bank.

In the formula bank there are computational formulas. The formula bank has its own input, checking and maintenance system. It can operate independently. Formula bank use factors such as FUSE-FORMULATION are provided to the blackboard for dispatching. The establishment of the formula bank makes formalizing and management of system knowledge easier.

The procedural expression is an indispensable knowledge expression method in the design model expert system. When a loop or recursion appears, procedure is the best method of expression.

3.2. Methods of Organizing Hierarchical Distributed Knowledge

At the present time there are two forms of organizing the knowledge used in expert systems, the "single form" and the "distributed form". In the "distributed form: of knowledge organization, under a single knowledge bank management system, knowledge is distributed and stored according to area, forming a number of knowledge banks, achieving control of the complexity of problem solutions.

The design process is generally broken down to stages and accomplished step-by-step. The tasks of problem solving can be broken down. The hierarchical distributed form of knowledge organization proposed in this article is shown in Figure 3. Each structure provides special knowledge of a special area or provides an individual function [6]. Through hook up with a cooperating intelligence structure, the system is make an intelligent problem solver.

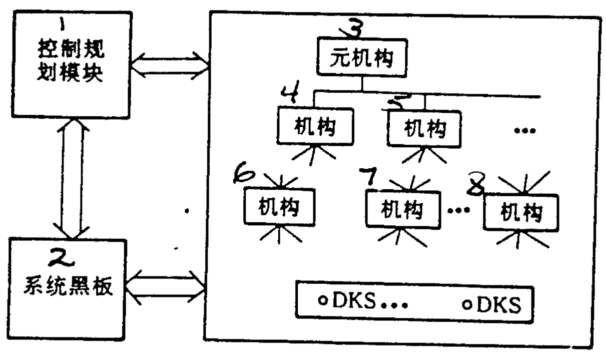

Fig. 3: Hierarchical distributed organization of knowledge

Key: 1. Control rules module. 2. System blackboard. 3. Unstructured. 4. Structure. 5. Structure. 6. Structure. 7. Structure. 8. Structure.

Each structure is generally composed of a single processing unit, one communications unit and its relevant knowledge. The structure has its own coprocessor which communicates and works together with other structures under the management of the blackboard. One knowledge source can serve multiple structures. After the structures are layered, in addition to being able to perform basic problem solving tasks, the higher layer structures are also capable of determining which structures must be executed or must cooperate to accomplish the task and alerting them of upcoming actions. The structures are only allowed direct communication between itself and its parent structure, sub structures or structures on the same level within the same connected structure. Information exchange between structures are primarily handled between the system's blackboard structure.

Research into Distributed Artificial Intelligence (DAI) and human brain theory have established the basis for the sixth generation of computers. This article has the structures hierarchical distributed organization achieve the following:

(1) Conform to engineering design requirements. Problem solving space can be divided up, and at the same time, the problem solving is done in stages and areas so the hierarchical organization form is most effective.

(2) Compared to the FA/C method, the is the additional structural overall rules concept.

(3) Compared to the multiple connection rules method, there is a tremendous decrease in amount of communications and machine time, and the range of structure cooperation is limited.

4. PROBLEM SOLVING STRATEGIES

4.1. Problem Solving

Compatible to the structural organizational form in Figure 3, the system uses the blackboard structure, meta-reasoning and schedule to control problem solving. The schedule is a structural execution rank listing. It is composed of operational functions. Each operational function calls an individual structure. It may be a single procedure or it may be a positive reasoning or reverse reasoning operations of a certain set of rules.

The selecting of relevant rules from a large knowledge bank is meta-reasoning. Correspondingly, meta-structure is the structure of the structure, the equivalent of a primary task programmer. Depending on the high level structural group required to operate to accomplish the task in the user's configuration, the meta-structure forms an initial schedule. The higher structures in the system break down the task through processing and communications elements, selecting lower level functional structures. In this manner, the system combines the reasoning of he control module and the higher level structures and using the blackboard on the schedule, thus determining the executional structures needed for the problem solving.

In ADDES systems, to design the forming die for a square box part, when allocating the task to the top level square box shaped part structure, if it is a deep box shaped part, then it requires the cooperation of the cylindrical shaped part structure. The first few formings are gradually made by a cylindrical part and the final forming is by the box shaped part. We can thus see that the schedule is continually revised and expanded in the design process.

4.2. Cooperation of Multiple Expert Systems

The system exchanges information between the various components through the blackboard to solve complex problems. The blackboard is the operational space for inquiries. The structures in the system are formed of one or several expert systems. This type of distribution type system is called a distributed expert system (DES). Each expert system is independent in its logic. They each have their own fields of knowledge and problem solving capabilities. Altering a certain expert system will not affect the other expert systems. The system achieves cooperation of the different expert systems through the blackboard structure.

A single expert system (ES) in the system is defined by its sub expert systems (substructures) as an ES= $\bigcup_{i=1}^{m}$ system. Thus, multiple expert systems (MES) can be defined as:

$$MES = (BLACKBOARD + SCHEDULE - LIST) + \bigcup_{i=1}^{n} ES_i .$$

5. CONCLUSIONS

In the discussion of organizing, and establishing die CAD expert systems and organizing the knowledge, we have explored the composition of engineering design CAD expert systems. Using special characteristic coding to establish user models and using the problem solving strategy of the use of hierarchical distributed forms of organizing knowledge and the blackboard structure, we have made the ADDES system intelligent, system problem solving, transparent and full of potential.

We can see that distributed artificial intelligence (DAI) and distributed expert systems (DES) are the trends in engineering design systems.

REFERENCES

1 Wang Q, Zhou J, Yu J. A chain–drive design expert system and CAD system. In: Gero J S ed. Expert System in Engineering. London: IFS Publications, 1988: 315–323

2 Howe A, Cohen P, Dixon J, Simmons M. DOMINIC: A domain–independent program for mechanical engineering design. In Gero J S: eds. Expert System in Engineering, London: IFS Publications, 1988: 361–371

3 Janson J J. ASDEP: An expert system for electric power plant design. In: Gero J S eds. Expert System In Engineering, London: IFS Publications, 1988: 217–234

4 Ohsuga S. Toward intelligent CAD systems. Computer Aided Design, 1989; 21 (6): 315–337

5. Fu Xiangyang, Gao Guangdao, Cai Qi, Drawing die design expert system part description and entry, Mechanical Science and Technology, 1991: (4), 73-77.

6 O'Hare G P. Designing intelligent manufacturing system: A distributed artificial intelligence approach. Computers in Industry, 1990; 15 (10): 17–25

7. Wang Shulin, Xu Duolun, A study of blackboard systems, Computer Science and Research, 1990: (10): 26-32

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